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Behavioral software engineering: A definition and systematic literature review

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ABSTRACT

Throughout the history of software engineering, the human aspects have repeatedly been recognized as important. Even though research that investigates them has been growing in the past decade, these aspects should be more generally considered.

The main objective of this study is to clarify the research area concerned with human aspects of software engineering and to create a common platform for future research. In order to meet the objective, we propose a definition of the research area behavioral software engineering (BSE) and present results from a systematic literature review based on the definition.

The result indicates that there are knowledge gaps in the research area of behavioral software engineering and that earlier research has been focused on a few concepts, which have been applied to a limited number of software engineering areas. The individual studies have typically had a narrow perspective focusing on few concepts from a single unit of analysis. Further, the research has rarely been conducted in collaboration by researchers from both software engineering and social science.

Altogether, this review can help put a broader set of human aspects higher on the agenda for future software engineering research and practice.

1. Introduction

Early in the development of the software engineering (SE) field it was recognized that one also had to consider the humans involved in software development (Weinberg, 1971). However, much of the research and practice in subsequent years focused mainly on technological or process-related factors while research that considered organizational, social or psychological factors was rare (Perry et al., 1994). Even if the introduction and focus on agile methods in the last 10–15 years has, yet again, highlighted the importance of people, teams and their communication and collaboration (Cockburn, 2006; Highsmith, 2002; Pikkarainen et al., 2008) these issues can still not be considered to be in the SE mainstream.

As an indication of this negative bias, we searched the ISI Web of Science and found that while 70% of papers in SE or software development also list a technology- or process-related topic less than 5% list a 'soft' or human-related topic.[1] Interestingly, even though this indicates there is still at least 10 times more technology- and process-focused research being carried out, our estimation shows that the percentage of research in ISI Web of Science that also considers softer, human aspects has increased from around 2% in 1993 to over 7% in 2013, more than a three-fold increase. Part of this increase can no doubt be attributed to an increasing number of workshops and outlets for this type of research (de Souza et al., 2009; Sharp et al., 2014).

While this growth is encouraging we argue that these concerns must be more generally considered in SE research. We and others have argued (Feldt et al., 2008; Fernando Capretz, 2014) that psychometric measurements should be taken into account in any SE research and there has been systematic literature reviews on other related aspects such as motivation (Beecham et al., 2008; Hall et al., 2009; Sharp et al., 2009), personality (Cruz et al., 2011) and organizational culture (Leidner and Kayworth, 2006). These are a key aspect when describing the context for SE research, which are so crucial to

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[1] We searched the ISI Web of Science on June 25th 2014 first for papers listing topics that match 'software engineering' or 'software development' and then checking how large a percentage of those that also list a topic among either a technology or process-related topic ('design', 'architecture', 'requirements', 'programming', 'testing', or 'verification') versus the ones that also list a 'soft' or human-related aspect ('social*', 'human factors', 'psychol*' or 'personality'). Even though this gives only a very coarse-grained indication we argue that it can at least act as a rough estimate of the relative amount of research done of each type.

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building generally useful theories and results (Petersen and Wohlin, 2009). If we miss these aspects, we risk producing results that do not uncover key factors in determining the success or failure of software projects. As an example, the human reluctance to change (Oreg, 2003) might be more important to consider in a software process improvement effort than exactly which process change is made or which tool is introduced. However, most research on software process improvement focus on the actual change rather than the people that will have to change their behavior (Unterkalmsteiner et al., 2012).

The main objective of this study is to clarify the research area concerned with human aspects of software engineering and to create a common platform for future research. In order to meet the objective, we propose a definition of the research area behavioral software engineering (BSE) and present results from a systematic literature review based on the BSE definition.

We argue that it is important to clearly define a specific area concerned with more realistic notions of human nature in order to better understand and improve software development processes and practices. In addition to the scientific value of having a clearly defined area of discourse we also argue that the definition is needed for political reasons. We need a definition and key concepts in arguments externally, to funding agencies and the society at large, as well as internally, to other SE researchers more focused on technical or process/method aspects of SE work. An inspiration is behavioral economics (see Section 2) and the relative importance that this sub-field of economics has gained in a relatively short time span.

Furthermore, the systematic literature review shall identify what have been studied, but also examine how the studies have been conducted. It aims to identify gaps in current research, identify trends and point to directions for future research. Thus, the primary focus of the SLR is the BSE research area as a whole, not the individual BSE concepts.

In the next section, we give further background and briefly present related research areas. After that, we present the methods used to define BSE and to conduct the systematic literature review. Next, the results are presented and discussed. Finally, the paper is concluded.

2. Background

More realistic understanding of the people involved in software development activities must be based on multiple scientific disciplines; software development is a very rich set of activities with connections to many existing fields. Over time, it is likely that many subfields of both psychology, social as well as organizational science will have to be considered for a fuller understanding of software development processes and practices.

In the following section we briefly describe the areas of research that we have deemed most relevant and that have affected our proposed definition and model of behavioral software engineering (BSE). These main areas are work and organization psychology, psychology in programming and behavioral economics. Below we also review how these topics have been described in different conferences and sub-areas within software engineering. Finally, we briefly describe software literature reviews in software engineering.

2.1. Related research

2.1.1. Work and organizational psychology

Psychology is defined as the scientific study of thinking, emotions and behavior. Naturally, organizational psychology[2] is the application of psychology in the workplace, i.e. concerned with 'behavior in the workplace' (Muchinsky, 1997).

[2] Also sometimes referred to as industrial and organizational psychology, occupational psychology, or work psychology.

Work and organizational psychology has only been in existence for about the last century. The question of what is significant for an individual's well-being and job satisfaction has been one of the most important research areas in organizational psychology since the 1920s. In the 1920s the research concentrated on physical work conditions such as lighting, ventilation and noise level and the beginning of the 1930s to the beginning of the 1940s, the interest in the social aspects of the work environment increased. In these years the human relations movement began, with Elton Mayo (1946) as one of its main spokesmen. Today work and organizational psychology raises important questions about how to manage effectively in organizations in particularly with the increasing number of knowledge workers whose commitment is critical to organizational success.

Knowledge workers such as IT consultants and software engineers live at the 'edge of change' such as new technologies and methods and the job involve a great deal of collaboration. Thus, this occupation has both a clear connection to other occupations that have been well studied within organizational psychology as well as at least a partly different context with unique aspects. It is important to study this occupation from the main perspectives of individual, group and organization.

2.1.2. Psychology of programming

According to Sajaniemi (2008), psychology of programming (PoP) is an interdisciplinary science that dates back to the late 1970s. The aim of PoP, which covers research in (1) computer programmers' cognition, (2) tools and methods for programming related activities and (3) programming education was originally to make the programmers work more efficiently and to produce better software.

The Psychology of Programming Interest Group (PPIG) was established in the late 1980s (Sajaniemi, 2008). The idea was to bring together researchers with a common interest in psychological aspects of programming but also to cover computational aspects of psychology. PPIG includes researchers from different communities such as cognitive science, psychology, software engineering, computer science etc. (Kutar, 2013).

Even though The Psychology of Programming Interest Group (PPIG) defines the term programming quite broadly to include any aspects of software development the annual workshop series the group hosts mostly emphasize the individual perspective of programming. The research methods discussed and used in PPIG most often have been adopted from cognitive psychology (Sajaniemi, 2008).

2.1.3. Behavioral economics

Behavioral economics (BE) is an interdisciplinary science which aims to establish descriptively accurate findings about human cognitive ability and social interaction with implications on economic behaviors and processes. It uses models and knowledge from several neighboring sciences, and the most influential neighboring science has been psychology (Rabin, 2002). Some scientists argue that psychological economics is a separate strand of behavioral economics which borrows solely from psychology, especially cognitive psychology (Tomer, 2007). Others, single out behavioral finance defined as the area that argues that some financial phenomena can be better understood using models in which some agents are not fully rational' (Barberis and Thaler, 2003).

Nowadays, behavioral economics is a prosperous scientific field with its own conferences and journals. It has had a broad effect on the scientific thinking in the area of economics. Daniel Kahneman received the Nobel prize in Economics in 2002 for his foundational work with Amos Tversky and gave his Nobel lecture on the 'Bounded maps of rationality: Psychology for behavioral economics' (Kahneman, 2003).

The state of affairs in SE shares similarities with the state of affairs in the field of economics before the more widespread acceptance

and rise of behavioral economics as one of its sub-disciplines.[3] While the prevailing assumption in economics during the 20th century has been that of human beings making rational choices in order to maximize their economic output, behavioral economists draw on psychology and sociology to explain economic phenomena (Bruni and Sugden, 2007). The research is thus grounded on hypotheses based on empirical data of how human beings actually think and behave. This fundamental shift in the basic assumptions of economics has helped create economic theories that can better account for the evident fact that humans show irrational as well as altruistic behavior, self-sabotage their own progress etc. (Lambert, 2006).

2.1.4. Conferences and workshops

A number of workshops and conferences have addressed concerns close to BSE over the years. Two examples are the workshop on cooperative and human aspects of software engineering (CHASE) and the psychology of programming (PoP) conference.

The CHASE workshops, which have been held in conjunction with the largest conference within SE (ICSE) since 2008, have highlighted two main strands: (a) human and (b) cooperative aspects of SE and emphasized that SE activities typically happen in the context of a group or team (Sharp et al., 2014). There has also been a special issue, based on work at CHASE, published in well circulated journals within the SE field (de Souza et al., 2009). The CHASE community has been key in creating more interest into human aspects on software engineering and the association with the main SE conference has surely helped in spreading the importance of these aspects.

The aim of PoP workshops, which covers research in (1) computer programmers' cognition, (2) tools and methods for programming related activities and (3) programming education, was originally to make the programmers work more efficiently and to produce better software. Even though the psychology of programming interest group (PPIG), which hosts the PoP workshop, defines the term programming quite broadly to include any aspects of software development the PoP workshop series emphasize the individual perspective of programming. The research methods discussed and used in PoP most often have been adopted from cognitive psychology (Sajaniemi, 2008).

A number of conferences, e.g. human-centered SE (HCSE) and conference on human factors in computing systems (CHI), have names that allude to this type of research but focus mainly on the human–computer interaction or on usability. Similarly, we acknowledge that there are many connections to the area of socio-technical systems and there have been several proposals for adopting such approaches to the design of software and information systems (Baxter and Sommerville, 2011). Even though there are plenty of and varied results and proposals in this area they are generally more focused on the system to be delivered and the people and organization that will use it rather than the people and organization that develop it.

2.2. Systematic literature review

A systematic literature review could be used to evaluate and interpret research for a particular field of interest. The guidelines suggested by Kitchenham (2004) have been derived from guidelines in medical research and adjusted to suite software engineering. The guidelines, which aims to create a fair evaluation by using a trustworthy, rigorous, and auditable methodology, include three phases—planning, conducting and reporting the review.

[3] Even the historic evolution of first acknowledging the importance of behavioral and psychological factors, then mostly ignoring them and then reintroducing them can be seen within economics (Bruni and Sugden, 2007; Lambert, 2006) and, thus, may indicate a natural progression in the maturation of any research field.

3. Methods

The following sections describe the method used to define behavioral software engineering (BSE) and the method used for conducting the systematic literature review (SLR).

3.1. Method for defining BSE

This section describes the overall process for developing the definition of the BSE research area. We discuss the need for a definition and describe the considerations that were made.

Given the background it is clear that there are a number of research areas that study or touch on different human aspects in relation to the development of software. However, the relation and/or overlap between them and what they cover is unclear. While research within psychology of programming focuses on the individual and one specific software engineering activity (programming) it puts less focus on other important activities or on the group and organizational levels. Even though both work and organization psychology as well as socio-technical systems highlight all these three main units of analysis (individual, group and organization), the former has no specific focus on software development while the latter focus on the use of the developed system rather than its development.

Work and organizational psychology uses the individual, group and organization aspects in order to give structure to the activities it studies (Furnham, 2005). Even though software development is different from many other types of work, it is unlikely to constitute a whole different type of human endeavor. Hence, we argue that these three aspects also are a relevant starting point to give structure to behavioral software engineering. The terms organization and group should here be considered in a general sense, i.e. the latter also includes different types of teams and other task-focused groups, while the former also includes more loose connections of multiple individuals such as communities.

We note that a problematic aspect of selecting the word behavioral for the main term of the proposed area of study is that a slight distinction is often made between social sciences (SS) and behavioral sciences (BS) in that the former has the group while the latter has the individual as their main units of analysis. We do not want to imply that BSE should not concern itself with different groups of software engineers, on the contrary we think such research will be essential for progress. Also, both SS and BS are often described as including the relationships among individuals in groups in their fields of study. Thus, even though we can alternatively use the names social software engineering or at least behavioral and social SE we argue that the former could give some a somewhat too narrow view of what is meant (psychological aspects of an individual developer not studied?) while the latter is somewhat long. Thus, we propose the shorter but still not optimal name of BSE as a compromise.

In an earlier publication (Lenberg et al., 2014), we proposed that BSE should be defined as the study of behavioral and social aspects of software engineering activities performed by individuals, groups or organizations. The definition was presented and discussed at the CHASE workshop in June of 2014.

Based on the discussion we propose two changes to the original definition. First, we want the definition to more clearly highlight cognitive aspects of SE. Even though this can be argued to be included within 'behavioral aspects' it is commonly used, implicitly or explicitly, in definitions even in the field of psychology as a whole. For example, the American Psychology Association describes psychology as the 'study of the mind and behavior' (American Psychology Association, 2014). We propose that cognitive is a better scientific term than using the more colloquial word 'mind'. Even though there is a slight risk that this can be interpreted as not as clearly including other aspects of mind, such as emotions and values etc., these are typically considered to be part of cognitive science. For example, the

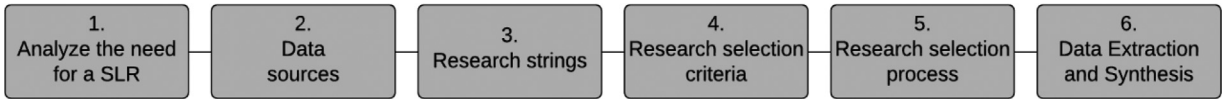

Fig. 1. Overview of the steps in the systematic literature review.

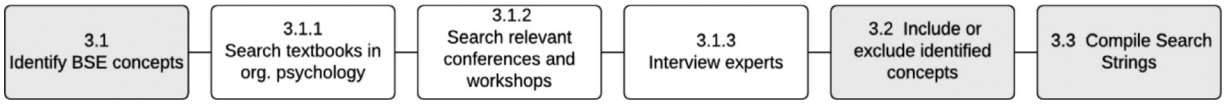

Fig. 2. Steps included to generate the search strings.

Stanford Encyclopedia of Philosophy defines cognitive science as 'the interdisciplinary study of mind and intelligence' even though it also notes that the field has often put less emphasis on emotions (Stanford Encyclopedia of Philosophy, 2014).

Second, we want BSE to include not only studies in relation to the activities within software development and engineering but also the studies of the individuals, groups and organizations themselves without a connection to a specific SE activity.

Based on these concerns we define behavioral software engineering (BSE) as the study of cognitive, behavioral and social aspects of software engineering performed by individuals, groups or organizations.

We appreciate that the processes of defining the BSE research area is iterative and that the definition will most certainly have to evolve as it is discussed further at conferences and workshops, and as the knowledge in the area refines.

3.2. Systematic literature review method

The SLR shall, as stated in the introduction, identify what have been studied in the BSE research area, but also examine how the studies have been conducted. It aimed to identify gaps in current research and research methods, identify trends and point to directions for future research. Thus, the primary focus of the SLR was the BSE research area as a whole, not the individual BSE concepts.

The SLR was based on the guidelines described by Kitchenham (2004). In order to reduce the possibility of researcher bias, a predefined review protocol was produced. The protocol described the review process, which included the following stages (also shown in Fig. 1), (1) analyzing the need for a systematic literature review, (2) selecting data sources, (3) selecting search string, (4) defining research selection criteria, (5) defining research selection process and (6) defining data extraction and synthesis. The next sections describe these stages in more detail and the considerations that we made.

3.2.1. Analyzing the need for a systematic literature review

For a detailed motivation, we refer to the reasoning in Sections 1 and 2 above. BSE is a unifying term that includes a large number of related concepts.

Existing systematic reviews have studied specific concepts but there is a lack of overviews that consider multiple concepts together. Since cognitive, behavioral and social sciences are all interdisciplinary with many interacting factors it is important that software engineering research also consider multiple factors within a single study and setting. This further motivates the need to complement existing systematic reviews with a broader, overview review.

3.2.2. Select data sources

BSE is interdisciplinary, therefore we selected databases likely to cover both technical as well as psychological research; IEEE Xplore Digital library, ACM Digital library, PsycINFO and Google Scholar. Even if the latter is not always recognized as a 'proper' research database we argue that it was important to be included here since the more topic-specific databases might not cover papers that are in between research areas and thus might have been published in less well known journals or conferences.

3.2.3. Search strings

The goal was to cover a substantial part of the BSE research area. Therefore, we identified concepts related to the definition. Since it was not possible to encapsulate the whole research area with a single string, multiple search strings had to be generated (Fig. 2).

3.1 In order to identify concepts related to cognitive, behavioral and social aspects of software engineering (see BSE definition in Section 3.1) we used a three-step process.
- 3.1.1 First, we identified concepts in work and organizational psychology textbooks (Chmiel, 2008; Engquist, 1992; Fahlke and Johansson, 2007; Forsyth, 2009; Hogg and Vaughan, 2002; Levitt and March, 1988; Maxwell, 2002; Nilsson and Waldemarsson, 2007; Senior and Fleming, 2006; Smith et al., 2003).
- 3.1.2 Second, we sought information in papers published in related conferences and workshops (see Section 2.1).
- 3.1.3 Third, we interviewed experts in the field of organizational psychology and social psychology.

3.2 Each identified concept was classified as a BSE concept or discarded. The criterion for classifying the concepts was simple and straightforward. If none of the authors found any argument that the concept was not aligned with the definition of BSE, i.e. would not contribute to study of cognitive, behavioral and social aspects of software engineering, the concept was included. The three authors did this process first independently and then discussed any discrepancies. There were very few discrepancies and they could easily be resolved in a discussion. The final 55 BSE concepts and a brief description of them can be found in Table 7.

3.2 Finally, one search string was generated for each of the 55 identified BSE concepts.

These are shown in Table 8.

The quality of the search strings was verified by a pilot search for two BSE concepts—self-efficacy and locus of control. For each concept, three relevant publications were known (Arya et al; Calisir et al., 2009; Darcy and Ma, 2005; Ozer, 2008; Ohly and Fritz, 2007; Tsai and Cheng, 2010) and the pilot search captured all of them.

We also considered other approaches for generating search strings. Instead of first identifying concepts related to the BSE definition and from these generate search strings, one option would be to use synonyms for 'human aspect' or 'human factors'. Although we think that the latter is a valid approach, we argue that the one we used has benefits. For example, we believe that it, by using multiple and more specific search strings, will be able find more relevant primary studies. In addition, the BSE concepts could be used to identify gaps in the research area and provide future research topics. One weakness is that the search strings will not find studies that do not include any of the BSE concepts and consequently they will not be

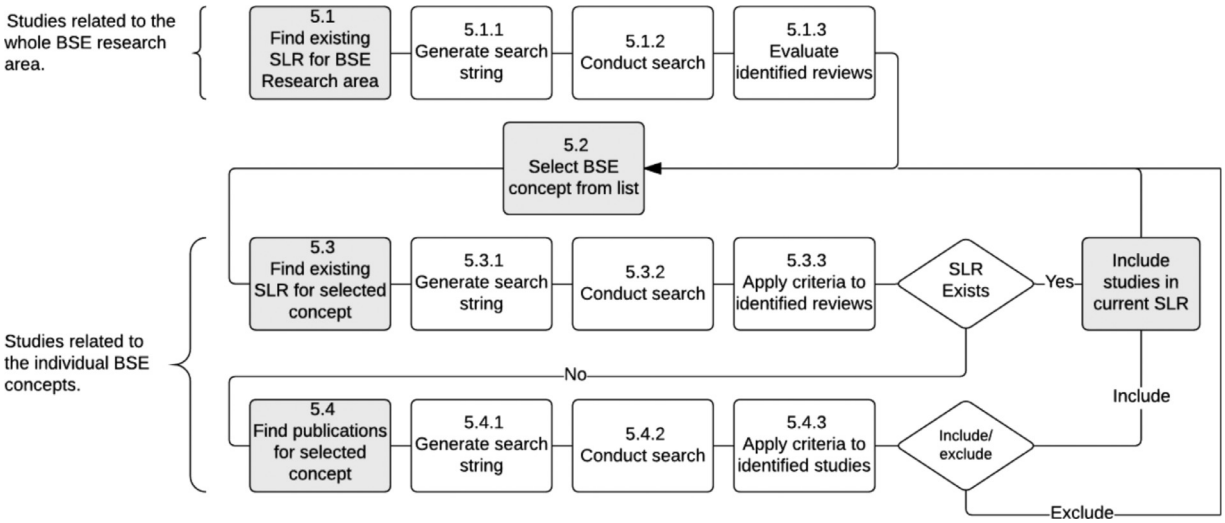

Fig. 3. Steps included in the selection process.

identified as primary studies. Hence, the number of identified primary studies is directly related to the number of identified concepts.

We recognize that we were not be able compile a complete list of all concepts related to BSE. However, we argue that the process described above ensures that we identify enough BSE concepts to fulfill the purpose of the SLR. We acknowledge that additional concepts will likely need to be added as the research area develops and gains a clearer sense of what it includes and studies.

3.2.4. Research selection criteria

The study selection criteria were intended to identify those primary studies that provide direct evidence regarding the aim of the systematic literature review (Kitchenham, 2004). In order to reduce the likelihood of bias, the following criteria were derived.

Inclusion criteria

Publication year: We limited the search to include publications between January 1997 and December 2013. This limitation was required since the number of search hits was very large despite of it. The start date was set in order to capture studies related to the agile software development approach, which has had a major influence on software engineering.

Publication type: We choose to include papers published both in journals, in conference proceedings and in workshop proceedings.

Content: The BSE concept had to have been studied in relation software engineering activities or to software engineers. No complete list of software engineering activities or software engineering roles was compiled. Instead, we used a publication by Yilmaz et al. (2012), and SWEBOK version 3 (Abran and Bourque, 2004) to provide general guidance.

Exclusion criteria

Language: We limited this study to only include papers written in English. Publication type: We excluded papers where we could not locate a full paper version, although very few papers were affected by this exclusion criterion.

A pilot of the selection process, described in the next Section 3.2.5, resulted in an update of the content criteria. The pilot showed that the researchers were unsure what roles to include in software engineering. Therefore, we added a publication by Yilmaz et al. (2012), and SWEBOK version 3 (Abran and Bourque, 2004) to provide general guidance.

3.2.5. Research selection process

As shown in Fig. 3 the research selection included three main step. In the first step we identified if there existed any reviews that covered a major part of the whole BSE research area. Next, we explored if there existed any literature reviews for the BSE concepts in Table 7. If no reviews were found, we identified studies related to the BSE concept. These main steps are detailed below.

5.1 First, we explore if any systematic literature reviews existed for the whole BSE research area.
- 5.1.1 The search string was generated by combining synonyms for system engineers (defined by Cruz et al., 2011) and synonyms for systematic review (defined by Biolchini et al., 2005) with a logical AND operator.
- 5.1.2 Next, the search string was applied to the selected data sources.
- 5.1.3 The search identified three meta literature reviews which listed literature reviews in the SE domain (Da Silva et al., 2011; Kitchenham et al., 2009,2010). In these studies three human factors literature reviews were found, all of which related to motivation (Beecham et al., 2008; Hall et al., 2009; Sharp et al., 2009). Further, the search identified literature reviews for motivation, stress, personality, intention to leave, organizational climate, organizational change and organizational learning. These studies are briefly described in the result Section 4.1. No literature review was found covering a substantial part of the BSE research area.

5.2 For each of the 55 BSE concepts identified in Section 3.2.2, the following steps were conducted.

5.3 We explored if any systematic literature reviews existed for the BSE concept.
- 5.3.1 The research sting was generated by combining synonyms for systematic review (defined by Biolchini et al., 2005) with the BSE concept with a logical AND operator. The search string for the BSE concept is shown in Table 8.
- 5.3.2 Next, the search string was applied to the selected data sources.
- 5.3.3 The criteria used in the evaluation are defined in Section 3.2.4. As suggested by Kitchenham (2004) the selection criteria were initially interpreted liberally, so that unless the identified systematic reviews could be clearly excluded based on titles and abstracts, full copies were obtained.

5.4 If a systematic review, conducted year 2008 or later, was identified for the BSE concept in the previous step, no additional

Table 1
Properties extracted for each paper in the systematic literature review.

Property	Description
P1: BSE concept	Sociological or psychological concepts included in the publication as defined in Table 7.
P2: Unit of analysis	The units of analysis are the major entities that are analyzed in the publication (Babbie, 2001). The publications were classified as individual, group or organization, based on the included BSE concepts. A publication could be classified as covering more than one unit of analysis.
P3: SWEBOK knowledge area	The published version of SWEBOK V3 (Abran and Bourque, 2004) has the following 15 knowledge areas (KAs) within the field of software engineering—software requirements, software design, software construction, software testing, software maintenance, software configuration management, software engineering management, software engineering process, software engineering models and methods, software quality, software engineering professional practice, software engineering economics, computing foundations, mathematical foundations and engineering foundations. If no clear knowledge area could be identified the property was assigned the value not applicable.
P4: Primary outcome	The property primary outcome was grouped into four categories; people, process, product or not applicable. People included outcomes that affect the individual's or group's norms, values, feelings, attitudes or behaviors, e.g. stress level, intention to quit, level of communication, etc. Process included extrinsic outcomes that affect individual's or group's way of work, processes, practices, methods or tools. Product included outcome related to quality of the developed product or system, the individual or group performance, efficiency or task success. Finally, if no clear primary outcome could be identified the property was assigned the value not applicable.
P5: Research design	Empirical or theoretical. In empirical studies the theories are supported through the collection of data rather than through theoretical reasoning. Theoretical studies develop new theories through analyzing existing theory and explanations, and the new theories are not verified through collecting evidence. For empirical studies, we also extracted if they used an experimental research design or not. We did not use a more detailed set of alternatives here since our internal validation showed that it was hard to reach consensus on which research design had been employed.
P6: Research context	Industrial, academic or not applicable
P7: Faculty affiliation	The faculty affiliation of the researcher(s) conducting the study, classified as (1) social sciences (i.e. anthropology, sociology or psychology, 2) software engineering or computer sciences, (3) other faculty or (4) unknown.
P8: Publication type	Journal, conference or workshop
P9: Publication year	Publication year

search was performed. If no systematic review was identified we explored if any studies existed for BSE concept.

5.4.1 The research sting was generated by combining synonyms for software engineers (defined by Cruz et al., 2011 and Beecham et al., 2008) and the BSE concept with the logical AND operator. The search string for the BSE concept is shown in Table 8.
For example, the research string for the BSE concept self-efficacy was ("self efficacy" or "self-efficacy") and ("software engineering" or "software development" or "agile development" or "systems engineering" or "systems development" or "software project").
A list of all 55 search strings are found in Table 8.

5.4.2 Next, the search string was applied to the selected data sources.

5.4.3 The criteria used in the evaluation are defined in Section 3.2.4. As suggested by Kitchenham (2004) the selection criteria were initially interpreted liberally, so that unless the studies could be clearly excluded based on titles and abstracts, full copies were obtained.
It was not possible to evaluate all search results returned by Google Scholar due to the large amount of results. Instead, for Google Scholar, if no relevant publications were included for three consecutive pages (10 results per page) the process was terminated. As a safeguard, random checks on at least 1% of the remaining results were performed.
On average, more than 500 papers were screened per BSE concept.

In order to verify the reliability, a selection process pilot was conducted in which two researchers applied one BSE concept (self efficacy) to Google Scholar. The pilot resulted in the constraint described in step [5.4.3] above.

3.2.6. Data extraction and synthesis

The properties to extract for each included paper were chosen to meet the primary purpose of the SLR. Table 1 shows the complete list of properties (P1–P9) each with a brief description, and, where applicable, its possible value range. Four properties (P1–P4) extracted information regarding what had been studied, i.e. what BSE concept(s) (P1) and what unit(s) of analysis (P2) had been studied, in what software engineering areas the research had been conducted (P3) and what were the primary outcome of the studies (P4). As shown in Table 1 the value range for these properties were nominal. In addition, P1–P3 could be assigned multiple values, while P4 only could be assigned a single value.

Three properties (P5–P7) extracted information related to how, or in what way, the studies had been conducted, i.e. what research design was used (P5), what were the research context (P6) and what faculties performed the research (P7). In addition, to get an overview of the BSE research area and identify temporal trends we also extracted the publication type (P8) and the publication year (P9).

In order to verify the reliability of the extraction process a pilot extraction was conducted, where three researchers classified 12 randomly selected publications (Brereton et al., 2007). Comparing the results from the researchers showed that the extraction process was straightforward for all properties except for P5, research design. Therefore, to reduce the risk of miss-classification we reduced the original number of choices leaving only two alternatives, empirical and theoretical studies.

In addition to extracting properties, we also summarized the actual contents and results for the studies. In these summations, we focused efforts on the studies including multiple units of analysis (UoA), i.e. studies that include concepts from more than one UoA. There were three main reasons for this choice. The first reason was primarily of a practical nature. It would not be possible to summarize and report on all of the 250 studies in this single paper. It was necessary to introduce some limitation otherwise this article would simply be too long. Second, the primary focus of the SLR was the BSE research area as a whole, not the individual BSE concepts. Hence, a summary of each study would not contribute to the purpose of this paper. Third, the definition of BSE emphasizes the UoA, and we believe it is of special interest to analyze studies that take on a broader approach, and that, in a way, cover a larger part of the BSE definition.

4. Results

The presented result follow the process described in the method section. First, we briefly present the existing SLR we identified and analyze them from a UoA perspective. Next, we present an overview of the SLR result, where we focus on the extracted properties (P1–P9) in Table 1. Finally, we summarize the multi-UoA studies, i.e. studies that cover BSE concepts from more than one UoA.

4.1. Existing literature reviews

We identified existing literature reviews related to four individual BSE concepts (motivation, stress, personality and intention to leave) and to three organizational BSE concepts (organizational culture, organizational change and organizational learning). No reviews were found for any of the group UoA concepts.

4.1.1. Individual UoA reviews

Four literature reviews were found covering motivation in SE (Beecham et al., 2008; França et al., 2011; Hall et al., 2009; Sharp et al., 2009). The reviews have an overall individual focus and showed that motivation mainly has been studied together with other individual UoA concepts. For example, Beecham et al. (2008) stated that software engineers are likely to be motivated according to individual concepts, i.e. their characteristics (e.g. their need for variety) and their internal controls (e.g. their personality).

Regarding models of motivation in SE, Sharp et al. (2009) conclude that the models in use heavily rely on the job characteristics model, which has a strong individual focus. The most recent review, conducted by Csar et al. (França et al., 2011) in 2011, summarize the research and state that there is no clear understanding of what motivates software engineers, how they are motivated or the benefits of motivating software engineers.

Ghapanchi et al. performed a literature to gain insight into existing studies on intention to leave of information technology (IT) personnel (Ghapanchi and Aurum, 2011). The review, which included 72 studies from 1980 to 2008, indicates that the research has had a broad perspective in terms of UoA. The authors identified 70 drivers and classified them into the five broad categories of individual, organizational, job-related, psychological, and environmental.

Regarding stress a relative small literature review by Maudgalya et al. (2006), which included 12 publications, identified a relationship between burnout and the variables job task, role ambiguity and role conflict. Hence, this review focuses on the individual UoA.

Further, a review by Shirley et al. (Cruz et al., 2011), which included 42 publications between 1970 and 2010, studied the BSE concept personality. The review shows that personality has been studied in conjunction with concepts from both the individual and the group UoA. For example, among the most recurring research topics was team building which is a group UoA concept. However, the review did not identify any publications that study personality together with a concept from the organizational UoA.

4.1.2. Organizational UoA reviews

Two reviews related to organizational learning were identified. These studies mainly focus on the individual and the organizational UoA, whereas the group aspect is not analyzed at all. A review by Bjørnson and Dingsøyr (2008) concludes that the research so far have been divided and have very little overlap. However, a major finding repeated over several studies is the need to not focus exclusively on explicit knowledge, but also on tacit knowledge. The first review (Robey et al., 2000) from 2000 identified two main streams of research: (1) studies that apply organizational learning concepts, and (2) studies concerned with the design of information technology applications to support organizational learning.

Further, software process improvement (SPI) is the most dominant organizational change paradigm that software organizations implement. Three reviews related to SPI were found. Common for all three studies were that they solely focus on the organizational UoA. The first review including 148 publications identified seven evaluation strategies (Unterkalmsteiner et al., 2012), where the most common pre–post comparison was applied in nearly half of the publications. The second review analyzed published case studies on the SPI efforts carried out in small and medium sized software enterprises (Pino et al., 2008). A review by Lavallée and Robillard, which included 26 SPI related studies, lists positive and negative impacts on software developers, e.g. that SPI is oriented toward management and process quality and not toward developers and product quality (Lavallée and Robillard, 2012).

A relatively small review by Leidner and Kayworth (2006) found three publications related to organizational culture in the SE domain published before 2004. A common finding in the three studies was the importance of a fit between the values on the group and organizational levels, e.g. the values of groups and the values embedded in the software development processes. This indicates that the research on organizational culture has had a broad perspective in terms of UoA.

4.2. Overview of the result

A total of more than 10,000 publication titles and abstracts were screened for relevance. After all the screening and filtering steps, 250 publications were finally included in the SLR. The included publications are listed per concept in Table 9 in the appendix.

4.2.1. What has been studied

Properties P1–P4 (unit of analysis, BSE concept, SWEBOK knowledge area and primary outcome) extracted information related to what had been studied in the included publications. As shown in Table 9, 42 of the 55 BSE concepts had 10 or less publications, and for 11 concepts no publications at all were found. Only seven concepts were studied in more than 20 publications. Even though no explicit search was conducted for personality this was one of the most common concept included in 31 publications. Other common concepts were communication (39 publications), group composition (24), job satisfaction (24) and leadership (23).

The researchers have so far focused on a few BSE concepts per study as can be seen in Fig. 4. Of the 250 publications 149 (60%) included only one BSE concept and only one publication include more than five BSE concepts. The average number of BSE concepts per publication was 1.5, with a median of 1 and a maximum of six concepts included in one publication. In addition, only 41 (16%) of the publications included BSE concepts from more than one unit of analysis (P2) and only three (1%) included concepts from all three units of analysis.

Further, the results indicate that the BSE research has focused on a few of the SWE-BOK knowledge areas (P3), see Table 2. In three of the 15 SWEBOK knowledge areas no related publications were found, and in nine of the areas less than five publications were found. The most common knowledge area (62% of the publications) was number 11 (software engineering professional practice). Worth noticing is that 27 publications (11%) focused on the software engineers themselves and studied them as individuals, or as a part of a group or an organization, without a connection to a specific knowledge area. An example of such a publication is Trimmer et al. (2000), which studies conflicts in software engineering.

As shown in Table 3, the primary outcome (P4) for 105 (42%) of the included publications was people. The distribution of the other outcomes was even, approximately 20% each. The individual UoA publications were more focused on the people factor than both the group and organizational UoA. For the organizational UoA only 16% had a

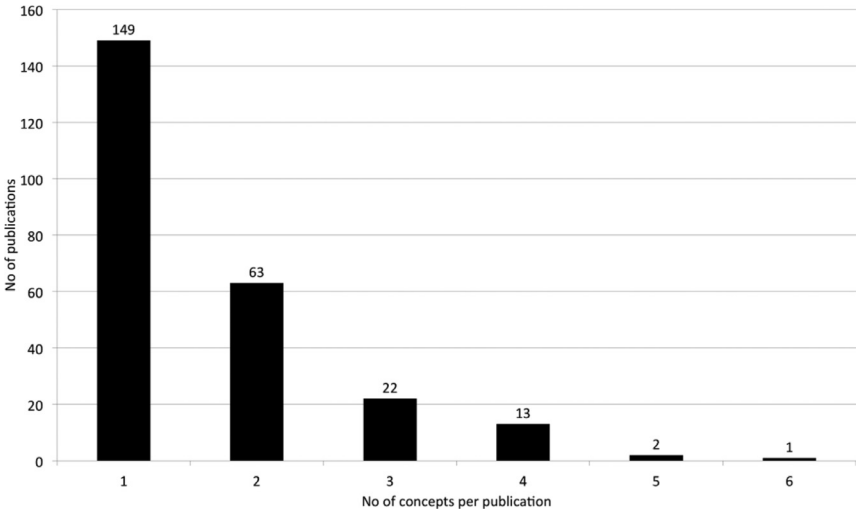

Fig. 4. Figure showing the number of BSE concepts per publication. For example, in 149 of the 250 publications only one BSE concept was studied.

Table 2
Result for P3—number of publications per SWEBOK knowledge area.

P3 - Knowledge Area	No. of publications
1: Software requirements	2 (1%)
2: Software design	2 (1%)
3: Software construction	11 (4%)
4: Software testing	2 (1%)
5: Software maintenance	0
6: Software configuration management	1 (0%)
7: Software engineering management	50 (20%)
8: Software engineering process	11 (4%)
9: Software engineering models and methods	31 (12%)
10: Software quality	3 (1%)
11: Software engineering professional practice	155 (62%)
12: Software engineering economics	37 (15%)
13: Computing foundations	0
14: Mathematical foundations	1 (0%)
15: Engineering foundations	0
Not applicable	27 (11%)

Table 3
Result for P4—number of publications per primary outcome.

P4: Primary outcome	Ind.	Group	Org.	All
People	78 (60%)	40 (32%)	6 (16%)	105 (42%)
Process	15 (11%)	2 (21%)	16 (43%)	55 (22%)
Product	22 (17%)	34 (27%)	4 (11%)	44 (18%)
Not applicable	16 (12%)	25 (20%)	11 (30%)	46 (18%)
Sum	131	126	37	250

people focus, while the figure was 32% for the group UoA. Unfortunately, the primary outcome property was insufficient for the organizational UoA publications and approximately 30% of these could not be assigned to any of the three defined classes people, process or product. Example of primary outcome for the unclassified studies was culture and climate.

4.2.2. How have the studies been conducted

Properties P5–P7 (research design, research context, faculty affiliation) extracted information regarding how, or in what way, the study had been conducted. The majority of the publications were empirical (76%). Approximately 80% of the individual and group UoA publications had an empirical research design, while the figure was around 60% the organizational UoA. Worth noticing is that only 13 (5%) publications used an experimental research design (see Table 4).

Table 4
Result for P5—number of publications per research design. For the empirical publication we also extracted, as stated in Table 1, how many that used an experimental research design.

P5: Research design	Ind.	Group	Org.	All
Empirical	104 (79%)	98 (78%)	22 (59%)	190 (76%)
Experimental	7 (5%)	8 (6%)	0 (0%)	13 (5%)
Theoretical	27 (21%)	28 (22%)	15 (41%)	60 (24%)
Sum	131	126	37	250

Table 5
Result for P6—number of publications per research context.

P6: Research context	Ind.	Group	Org.	All
Industry	80 (60%)	66 (52%)	20 (54%)	141 (56%)
Academia	25 (19%)	31 (25%)	1 (3%)	46 (18%)
Ind. and acad.	10 (7%)	4 (3%)	2 (5%)	13 (5%)
Not applicable	19 (14%)	25 (20%)	14 (38%)	50 (20%)
Sum	134	126	37	250

As shown in Table 5, most of the publications (56%) were conducted in an industrial context, 18% in an academic context, 5% used dual contexts and 20% had no clearly identifiable research context. The organizational UoA have, naturally, a smaller proportion of publications in an academic context than the other UoA; it is hard to study an organization out of context.

Regarding the faculty affiliation (P7), 32 of the publications, approximately one in eight, had a researcher from a social science faculty, and 10 publications, one in 25, had researchers from both the software engineering and social sciences faculties.

4.2.3. Publication type and temporal distribution

The distribution between publication types (P8) differs slightly between the UoA. The individual UoA had a greater proportion of conference publications and smaller proportion of journal publications than the group and organizational UoA. 154 (62%) were journal

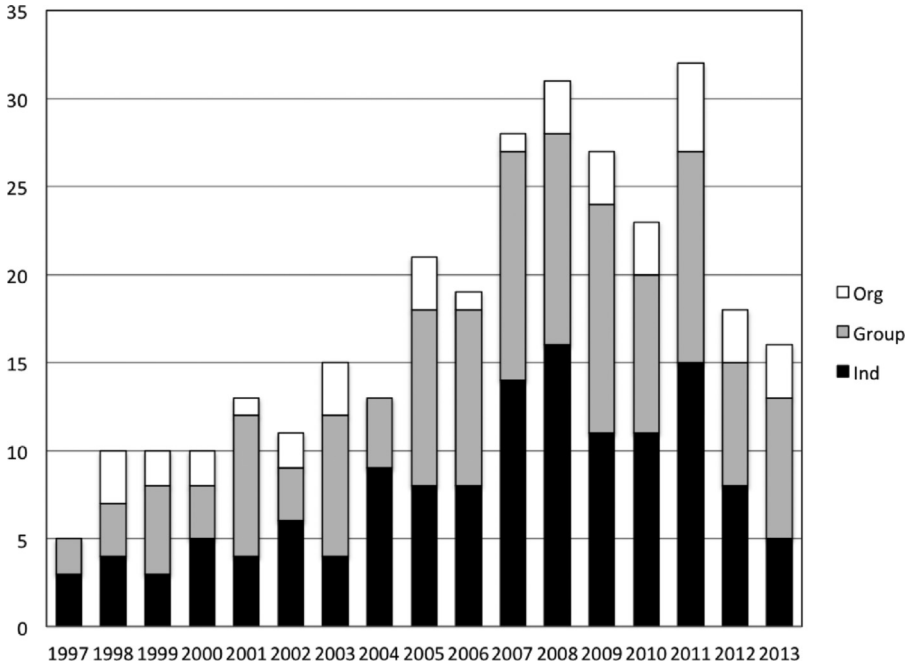

Fig. 5. Temporal distribution of included papers per UoA.

Table 6
Result for P8—number of publications per publication type.

P8: Publication type	Ind.	Group	Org.	All
Journal	74 (56%)	81 (65%)	26 (70)	154 (62%)
Conference	51 (39%)	34 (27%)	9 (24%)	80 (32%)
Workshop	6 (5%)	10 (8%)	2 (5%)	16 (5%)
Sum	131	125	37	250

publications, 80 (32%) were conference publications and 16 (6%) were workshop publications (see Table 6).

The temporal distribution (P9) for all the publications is shown in Fig. 5. As can be seen, the general trend is that the number of BSE relevant publications is increasing with time. It is too early to decide if the downward trend seen for the last 2 years reflects an actual decrease or if not all publications have yet found their way to the databases. In particular, this might be a challenge with Google Scholar.

4.3. Multi-UoA studies

This section focuses on the multi-UoA publications, i.e. the publications that include BSE concepts from more than one UoA. The definition of BSE emphasizes the UoA, and it is therefore of special interest to analyze publications that take on a broader approach, and that, in a way, cover a larger part of the BSE definition. We present which concepts are the most common among these publications (see Fig. 6 and we also briefly summarize result of the multi-UoA publications.

Of the 250 included publications, only 41 (16%) covered more than one unit of analysis (UoA). Of these, 38 covered two UoA and only three covered all three UoA. As shown in Fig. 6, the multi-UoA studies included 30 of the 55 BSE concepts, and the most frequent concepts were personality (included in 20 publications), communication (13) and group composition (11).

4.3.1. Individual-group studies

Of the multi-UoA studies, the individual-group combination was, with 32 studies, the most common. The top three combinations of BSE concepts were personality-group composition (nine studies), personality-communication (7) and personality-conflicts (3). A study by Pieterse et al. (2006) showed that personality diversity was a strong predictor of success, especially during the initial phases of team growth. The single most common tools used in the personality-group composition studies were Myers-Briggs Type Indicator (MBTI) (Lewis and Smith, 2008a, 2008b; Licorish et al., 2009; Omar and Syed-Abdullah, 2010; Peslak, 2006; Rutherfoord, 2001). It was used both to verify personality as a factor in teams and as a base to assemble teams.

Only one of the studies that included personality and communication concepts investigated their relationship explicitly. This study showed that divergent teams, i.e. teams including members with different personalities, positively correlated with communication quality (Sfetsos et al., 2006). In the other studies these concepts, i.e. personality and communication, were used as separate independent variables when studying pair and team programming (Choi, 2007; Choi et al., 2009; Salleh et al., 2011), and team performance (Bradley and Hebert, 1997). Though, the results of these studies were inconclusive.

Further, three studies included the concepts of personality and conflict. Two studies by Lewis and Smith, which used problem-solving style, found that the diverse groups reported less conflict and fewer negative comments than the dominant groups (Lewis and Smith, 2008a, 2008b). The study also concluded, as the authors expected, that there was a significant negative correlation between conflict and performance. The negative effects of conflicts were also acknowledged in a study by Acunã et al. (2009) which found that the level of satisfaction and cohesion dropped the greater the level of task conflict there was among team members. The same study also found a correlation between an average score for the personality factor extraversion and the evaluated quality of the developed software product.

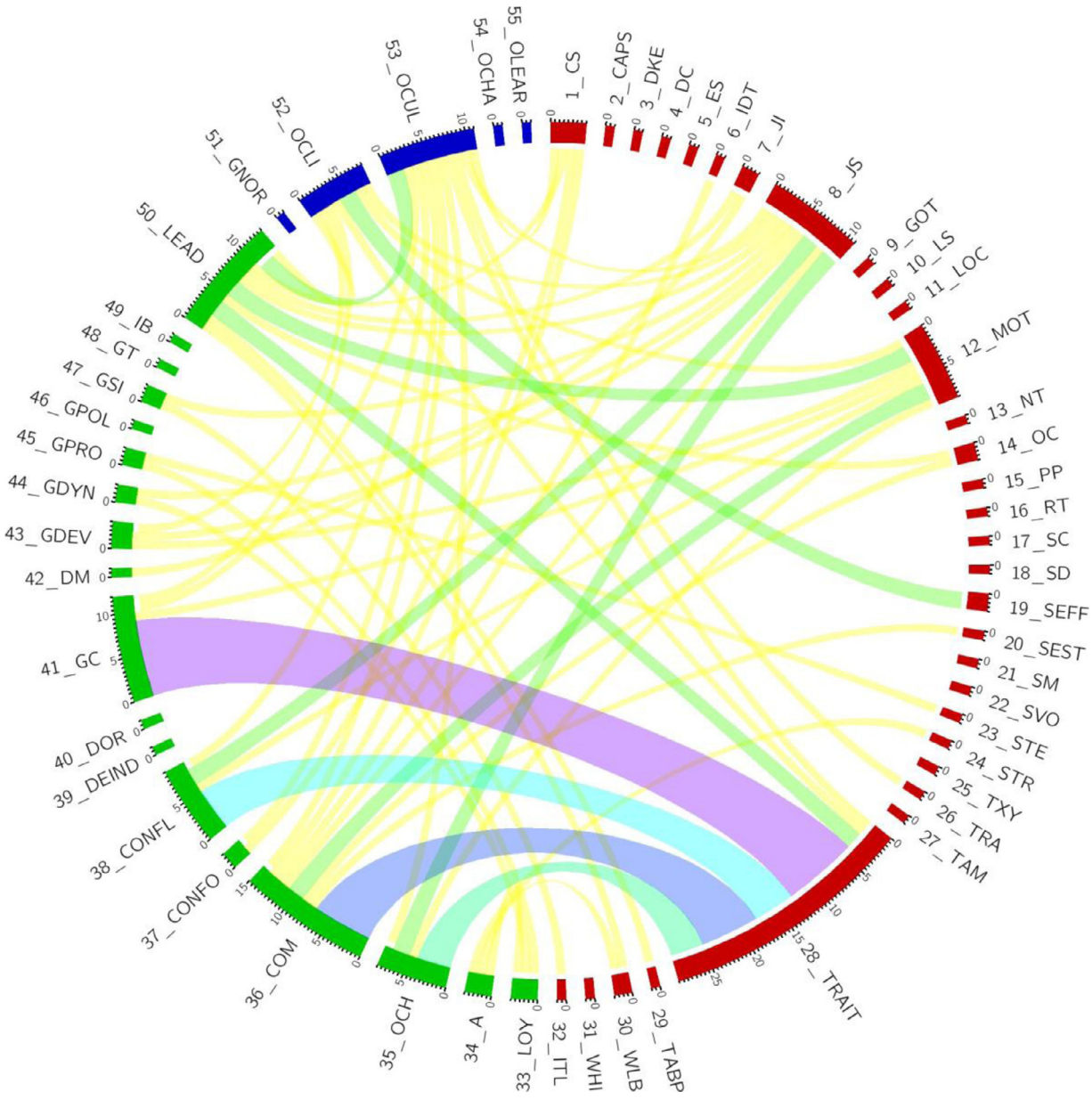

Fig. 6. The figure shows which BSE concepts that have been studied together. The colors in the outer circle relate to the unit of analysis, where red represents the individual BSE concepts, green the group concepts and blue the organizational concepts. The size of the curved lines connecting the concepts relate to the number of publications where the connected concepts have been studied together. The figure shows, for example, that the BSE concept personality (28 TRAIT) has frequently been studied together with group composition (41 GC) and communication (36 COM); whereas inter-group behavior (49 IB) has not been studied together with any group or organizational BSE concept. The abbreviations in the figure are shown in Table 9. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4.3.2. Individual-organization studies

Three studies included concepts from both the individual and the organizational UoA. First, a study by Tsai and Cheng (2010) concluded that organizational climate has a positive effect on self-efficacy, which in turn has a positive effect on the intention to share knowledge. Second, using theory of planned behavior (TPB) Passos et al. (2013) formed a conceptual framework in which organizational culture was identified as a component affecting the behavioral intentions (Passos et al., 2013). The results pointed to a strong influence of past experience and showed that it is possible to characterize belief systems in software project contexts within a behavioral perspective. Third, results from a field study (Trimmer et al., 1998) indicated that individual personality (e.g. personality, self efficacy) differences and factors of the work environment (e.g. organizational climate) do affect professional competency levels.

4.3.3. Group-organization studies

In a meta study Sudhakar et al. (2011) found that soft factors such as group composition and organizational climate had an effect on software development team performance. Further, an action research study reported on the importance of communication and organizational learning for virtual teams (Suchan and Hayzak, 2001). Last, in a study related to the culture and conflict concepts Leidner et al. developed themes of IT-culture, upon which they then formed a theory of IT, values, and team conflicts. Based upon the theory, they developed propositions concerning three types of cultural team conflicts and the results of these conflicts (Leidner and Kayworth, 2006).

4.3.4. Individual-group-organization studies

Excluding the literature review (Dybå and Dingsøyr, 2008) only two (1%) of all included studies included all three units of

analysis. A model for individual adoption of technology was presented by Sultan and Chan (2000), which include group (communication, leadership), and organizational (organizational culture) concepts. The study showed that the proposed model predicted which employees that will adopt new technology with an accuracy of 86%. Using a research model analyzing organizational learning and group development effect on job satisfaction, Janz examined the effects of self-directed work teams (Janz, 1999). Results indicate that the level of cooperative learning that takes place on the teams may be more important to achieving improved work outcomes.

5. Discussion

5.1. Result summary

Based on a definition of the behavioral software engineering (BSE) research area this study performed a systematic literature review (SLR). Over 10,000 publications were screened into a final set of 250 BSE publications included for detailed analysis. Together with existing literature reviews, our review provides an overview of this growing area of software engineering research.

The results from the SLR indicate that the BSE research area is growing and considering an increasing number of concepts from psychology and social science, at least for the investigated years 1997–2013. But the results also show that there are gaps in BSE research; several concepts that are widely considered to be part of organizational and work psychology have not yet been studied in SE. There are also a number of SE areas where no BSE research has been performed. Furthermore, the result indicates that the research performed so far have been unbalanced, with a heavy focus on a few BSE concepts on a limited number of SE areas.

BSE is an increasingly important aspect of SE research and should be recognized as such. Clarifying its definition and creating an initial list of concepts that it includes should help this type of research be more commonly considered by SE researchers and practitioners alike.

5.2. Overall trend

The total number of relevant BSE publications is larger than what is often assumed (Fernando Capretz, 2014; Feldt et al., 2008) and with more than 250 publications since 1997 the research area is neither new nor unresearched. Though, the results indicate that the research so far has been unbalanced both in terms of which BSE concepts that are studied, and in terms of which SE areas the concepts have been studied in.

For more than half of the identified 55 BSE concepts less than five publications were found, and for 11 concepts no publications were found. The BSE research has so far focused on a few well-known concepts, which also is supported by the fact that nine of the concepts include more than 15 publications each. The same pattern can be seen for the SE knowledge areas defined in SWEBOK, where the research so far has been focused on a selective few.

The top studied BSE concepts, with the most included studies, are communication, personality and job satisfaction. [4] The result shows three categories of publications related to communication; publications that stress the importance of communications, publications investigating factors affecting communication and publications focusing on the impact of different types of and amount of communication. The research was unanimous regarding the importance of communication, and it was recognized as an important factor in several areas, e.g. in distributed team environments (Jiménez et al., 2009) and as a skill for team members and project managers (Napier et al., 2009). The publications identified several factors that affected the communication, examples of such are team composition (Lewis and Smith, 2008a, 2008b) and agile methodology (Pikkarainen et al., 2008). Furthermore, the result showed that communication quality has an impact on e.g. product quality (Ikonen and Kurhila, 2009) and organizational trust (Lowry et al., 2010).

Regarding personality, the result in this study confirms previous research (Cruz et al., 2011) and the most common themes, where personality was used, were in relation to pair programming and team composition. The most commonly used test was MBTI followed by tests based on the five factor model. Furthermore, the included studies also support the conclusion in previous research that evidence in some cases are inconclusive (Cruz et al., 2011). For example, this applies to the common theme of pair programming, where the research is inconclusive regarding if teams with different personality perform better compared to homogeneous teams (Katira et al., 2004, 2005; Salleh et al., 2011; Williams et al., 2006).

Most of the job satisfaction related studies investigated factors that affect job satisfaction. The research has so far been rather fragmented in the sense that it is unusual that several studies examined the same factors. Examples of factors reported to have a positive effect on job satisfaction are organizational trust (Scholarios and Marks, 2004) and high job fit (Lee and Gallivan, 2011). Factors with a negative effect on job satisfaction are role conflicts and role ambiguity (Shen, 2005). Four studies showed, as expected, that job satisfaction was related to the intention to quit (Buche, 2008; Calisir et al., 2009; Tseng and Wallace, 2012; Westlund and Hannon, 2008).

That a number of BSE concepts and SWEBOK knowledge areas are un-researched also implies that there are gaps in current research and that more research is needed. A threat to this conclusion is that the list of BSE concepts we identified is incorrect or misaligned and that (some of) the BSE concepts are not applicable to the SE domain. Even though we recognize this possibility, we consider it unlikely for all BSE concepts with few or no studies. It is our opinion that the methods described in Section 3, which are used to identify the BSE concepts and perform the SLR, reduce the risk of making such errors.

At the individual UoA, we believe that SE research could benefit by broadening the focus from the commonly studied personality traits, e.g. MBTI (Capretz, 2003; Choi et al., 2009; Katira et al., 2004, 2005; Mourmant and Gallivan, 2007; Williams et al., 2006) and five factor models (Acunã et al., 2009; Feldt et al., 2008; Judge et al., 2002; Lounsbury et al., 2009).

There are several unexplored BSE concepts at the individual level that might of interest, e.g. social value orientations (SVO) (Beggan et al., 1988). The SVO construct has its origin in social psychology, but has also been studied in other disciplines (Nauta et al., 2002) and may well be applicable within SE. In addition, when it comes to the group UoA we expect to find a number of important BSE concepts that can be considered. In particular, since the focus on and importance of the group has increased and been more clearly recognized with the use of agile development methodologies. As one example, a potentially important concept can be group polarization (Myers and Lamm, 1976), a phenomenon that when placed in group situations, people will make decisions and form opinions to more of an extreme than when they are in individual situations. We did not find any papers that consider the concept within SE.

As a general strategy for the research area we propose that exploratory research that consider several BSE concepts at the same time could be helpful. Such studies can help create understanding of which concepts should be considered in more detail in subsequent research and which ones can be excluded. As an example, Kosti et al. recently considered emotional intelligence and self-compassion in a software engineering context but found that the former added only

[4] We do not count all the papers in the concept-specific systematic literature reviews; only the ones in our set of included papers.

very little improvement in terms of predictive power compared to trait personality psychometrics (Kosti et al., 2014).

5.3. Units of analysis

Of the included publications, 41 (16%) covered concepts from more than one UoA and only three (<1%) include concepts from all three UoAs. That only three studies covered all three UoA depends to a certain degree on that there are currently only four organizational BSE concepts. Still, we believe that the concepts on different UoA are related to and dependent of each other, and that the behavior of humans is too complex to be described using only one UoA. Klein et al. (1999) state that multi-UoA theories are desirable because they provide a deeper and richer portrait of organizational life, and according to Crowston (2000) many organizational issues are multi-UoA and thus incompletely captured by single-UoA theories. We also believe that the multi-UoA studies are needed from an industrial perspective. For example, from a management point of view the understanding of what effects a change in the organizational level has on the group and individual level and vice versa is valuable information, making it possible to understand the consequences of the decisions to be taken.

There are without any doubt many reasons for the lack of multi-UoA studies. Klein et al. identified five barriers that relate to these types of studies. The first barrier is simply the mass of potential and relevant research. The second relates to the interest, values and heuristics of the researchers, i.e. the researcher are not used to these types of studies. The third barrier is the difficulty to determine the scope of the multi-UoA theory. The fourth barrier is the difficulty to publish, i.e. multi-UoA studies seem to belong everywhere and nowhere. The fifth and final barrier is the difficulty and complexity of conducting multi-UoA research, a barrier also supported by Crowston (2000).

5.4. Interdisciplinary research

Further, the result from the SLR shows that 13 (5%) studies used an experimental research design. Compared to SE studies in general this figure is quite high. Sjøberg et al. showed that only 1.9% of over 5000 SE publication between 1993 and 2003 reported controlled experiments (Sjøberg et al., 2005). However, compared to work and organizational psychology (WOP) this figure is low. In a literature review Austin et al. (2002) sampled and analyzed in total 609 empirical studies that were published in every 10th volume of *Journal of Applied Psychology* from 1920 to 2000. The study showed that experimental designs were the second most common research design and used in approximately 30% of the studies for the last two decades prior to the study (i.e. 1980s and 1990s).

A possible reason for the difference in terms of research design between WOP and BSE can be related to the background of researchers and their faculty affiliation. Our results show that only 32 publications, approximately one in eight, had a researcher from a social science faculty, and that 10 publications, one in 25, had researchers from both the SE and social science (SS) fields. The absence of social scientists has also been noted in previous research (Cruz et al., 2011). Even though our result gives only an indication, since the affiliation might not correctly describe the specific background or experience that a researcher has, it supports our conclusion that BSE researchers in general should seek more cross-faculty collaborations.

We argue that BSE would benefit from becoming even more interdisciplinary, meaning that more studies should be performed in collaboration by researchers from SE and SS faculties. The social sciences have over hundred year of history of studying human behavior (Richard et al., 2003). Clearly, the knowledge that has been built up could be leveraged for research in BSE not only directly (subject matter) but indirectly, through selected research approaches and methods. Without a broad, serious and systematic consideration of social science results and methods, SE researchers risk having to invent the wheel again and again. On the other hand, software engineering is a complex activity and the SS researchers need the SE researchers domain knowledge in order to design proper studies and analyze results. As the importance of software in society grows it seems likely that more behavioral and social science researchers will find software projects and organizations a viable area for specialization (Beecham et al., 2008).

5.4.1. Limitations of this study

We have identified the following main threats to the validity of our results based on the methods we have used: (1) publication selection bias, (2) identification of publications, (3) inaccuracy in data extraction, and (4) mis-classification.

Publication selection bias is the phenomena where more positive than negative research results tend to be published, which can lead to an overestimation of the effect size in systematic reviews and an under-reporting of risks (Kitchenham et al., 2004). We regard this risk as moderate, and to reduce it we did not restrict the sources of information to a certain publisher, journal or conference. Further, we did not include gray literature (technical reports, books, etc.) as these tend to be secondary sources (Genero et al., 2011). Some relevant papers may therefore have been excluded. Also, to help ensure an unbiased selection process, we defined the purpose of the study in advance, organized the selection of articles as a multistage process and documented the execution.

We acknowledge that the included publications do not cover the entire BSE research area. First, the result of the SLR is directly related to the identified BSE concepts, which, as stated previously, only acts as a starting point and does not cover all conceivable concepts. Though, we argue that the database and search string selection combined with the choice to include journal, conference as well as workshop proceedings ensure that the included publications will constitute a representative part of all publications, and that we will identify a sufficient number of studies to meet the purpose of this study. In addition, the search string quality was verified by a pilot search for the BSE concepts self-efficacy and locus of control. For each of these two concepts three relevant publications were known and all of them were captured in the pilot search. Since BSE is a nascent area of research and covers a multitude of different topics it is hard to identify a clear 'golden set' of publications that our search should have identified. With time this threat can more easily be mitigated. In fact, our results can help future researchers create such 'golden sets' for specific UoA's or concepts.

The selection and the data extraction process were mainly conducted by a single researcher. Although this approach is weaker in terms of consistency than having multiple researchers conducting the complete extraction in parallel and cross-checking the result, it was a necessary trade off in order to fulfill the schedule and the targeted breadth of the systematic review. To mitigate the threat we validated the steps through a random sampling of papers from which the other authors extracted results. However, since we cannot guarantee that some papers have not mistakenly been excluded or missed we have been careful, in our analysis, not to draw any conclusions based on a single paper or a single concept. Rather, the discussions and conclusions are related to the research area as a whole and reflect the overall trends.

Finally, our approach in this study has been to assess and evaluate research concerned with behavioral aspects of software engineering from a psychological perspective. This chosen interdisciplinary approach has affected the methods used in the systematic literature review. For example, the primary studies included in the SLR are related to psychological concepts found in work- and organizational psychology literature. It is our experience, from attending workshops and conferences, that some SE researchers perceive this approach as rather controversial. One reason for the skepticism might very well

be related to the difficulties in conducting interdisciplinary research (Campbell, 2005; Heberlein, 1988; Miller, 2011). For example, Miller (2011) states that an initial difficulty in interdisciplinary research is a terminological problem across the disciplines, where terms used in each discipline mean such different things that problem arise due to disagreements over those definitions and how to use the terms. The later problem can at least partly be mitigated by, and thus also further motivates the need for, the BSE definition and a future taxonomy. They can help provide a common communication platform among BSE researchers as well as toward social science researchers. However, we acknowledge that the present definition and investigated topics are not the final say in this regard; we can only claim to take an initial step and hope that others can build on and refine it.

6. Conclusions

Human aspects of software engineering are a growing area of research that has been recognized as important for a long time. Even though research that considers them has been growing in the past decade, these aspects should be more generally recognized and considered.

Therefore, in this study we present an updated definition of the behavioral software engineering (BSE) research area and conduct a systematic literature review based on identified concepts aligned with the definition.

The definition highlights that BSE is the study of cognitive, behavioral and social aspects at different levels relating to the work of software engineers. It is focused on the software developers and engineers themselves or in aggregates but excludes human aspects in relation to the use of the actual software; the latter is already studied in the human–computer interaction (HCI) field.

We found a total of 55 related concepts from organizational and social psychology and classified them as belonging to one of three main units of analysis. Even though these concepts are not likely to be complete it includes more concepts than has been previously considered together. As the area matures the number of concepts can expand to include a more refined view of relevant concepts.

The main results from our systematic review are that there are gaps in the existing BSE research and that the research has been unbalanced. For 11 out of 55 concepts, we found no published papers and for nine concepts we found more than 15 publications per concept. Thus, the research so far has had a heavy focus on a few BSE concepts that have been applied to limited number of SE areas. Existing BSE research focuses on software engineers, teams or organizations in general and is not frequently connected to a specific phase or activity. Only one or a few (mean is 1.5, median is 1, max is 6) BSE concepts are included per study. Further, the result shows that the research seldom focuses on multiple units of analysis, and that it rarely is conducted in collaboration with researchers from both the software engineering and social science faculties. BSE is inherently applied and real-world; a majority of studies are empirical and conducted in an industrial context. In contrast to research in psychology, BSE research also less commonly use experiments, even if they are used more in BSE than in SE in general.

We have argued that future BSE research would benefit from focusing on several units of analysis and becoming more interdisciplinary, meaning that more studies should be performed by researchers from both software engineering and social science faculties. At least, SE researcher should explore more concepts within the cognitive, behavioral and social sciences and build on the many results from these areas. These scientific fields have over hundred years of history of studying different aspects of human behavior. Clearly, this gained knowledge could be leveraged for research in BSE and can help create a richer understanding of how humans involved in software development and engineering behave, think and feel. Software engineers as well as the end users of the software they produce stand to benefit.

Acknowledgments

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Appendix

Table 7
BSE concepts and description.

BSE concept (UoA)	Description
Cognitive style (I)	Individual differences regarding strategies for perceiving, remembering, thinking, and problem solving (Messick, 1984).
Cognitive affective personality system (I)	A theory for personality that states that behavior is explained by the personality, the situation and the integration between them (Mischel and Shoda, 1995).
Dunning–Kruger effect (I)	A cognitive bias that refers to the seemingly pervasive tendency of poor performers to overestimate their abilities and for high performers to underestimate their abilities (Kruger and Dunning, 1999).
Demand control (I)	In the model, workplace stress is a function of how demanding a persons job is and how much control the person has over their own responsibilities (Karasek, 1998).
Explanatory style (I)	The model refers to how people explain why events happen in their lives, either positive or negative. There are three components in explanatory style; personal (internal vs. external), permanent (stable vs. unstable) and pervasive (global vs. local) (Seligman and Schulman, 1986).
Job insecurity (I)	A state or condition wherein individuals lack the assurance that their jobs will remain stable (Greenhalgh and Rosenblatt, 1984).
Job satisfaction (I)	Defined by Locke as a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences (Locke, 1976).
Goal orientation (I)	Defined by VandeWalle as disposition toward developing or demonstrating ability in achievement situations (VandeWalle, 1997).
Life satisfaction (I)	Life satisfaction measures how people evaluate their life as a whole rather than their current feelings (OECD, 2014).
Locus of control (I)	In personality psychology, locus of control refers to the extent to which individuals believe they can control events affecting them (Rotter, 1966).
Motivation (I)	According to Pardee (Pardee, 1990) motivation can be defined as those forces within an individual that push or propel him to satisfy basic needs. It is what prompts a person to act in a certain way or at least develop an inclination for specific behavior.

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Table 7 (*continued*)

BSE concept (UoA)	Description
Need theory (I)	A motivational theory developed by David McClelland in the 1960s that explain how the needs for achievement, power and affiliation affect the behavior (McClelland, 1987).
Organizational commitment (I)	Organizational commitments is a positive evaluation of the organization and the organizations goals (Sheldon, 1971).
Positive psychology (I)	Positive psychology is the branch of psychology that study the strengths and virtues that enable individuals and communities to thrive (Seligman and Csikszentmihalyi, 2000).
Risk taking (I)	Risk taking is the tendency to engage in potential harmful behavior that, at the same time, could have some kind of positive outcome (March and Shapira, 1987).
Self control (I)	Self control, or self regulation, is a persons ability to control emotions, behavior and desires, and to limit impulses (Duckworth, 2011).
Self discipline (I)	The act of disciplining or power to discipline one's own feelings, desires, etc., esp. with the intention of improving oneself (Dictionary, 2014).
Self efficacy (I)	Is the extent or strength of persons belief in his or her own ability to complete tasks and reach goals (Bandura, 1982).
Self esteem (I)	A person's overall emotional evaluation of his or her own worth (About.com, 2014).
Self monitoring (I)	Is the ability to observe and evaluate your own behavior (Snyder, 1974).
Social value orientation (I)	The stable preferences for certain patterns of outcomes for oneself and others, e.g. how to allocate resources (e.g. money) between your self and another person (Griesinger and Livingston, 1973).
Stereotypes (I)	A thought that can be adopted about specific types of individuals or certain ways of doing things, i.e. a fixed and over generalized belief about a particular group or class of people (Cardwell, 2014; McGarty et al., 2002).
Stress (I)	Defined by the American Psychological Association as a transient state of arousal with typically clear onset and offset patterns (Association, 2014).
Theory X theory Y (I)	Theories of human motivation, more specific the perceptions managers hold on their employees (McGregor, 1960).
Theory of reasoned action (I)	Is a model for the prediction of behavioral intention, attitude and behavior, where an individuals behavior is determined by his or her's intention to perform the behavior. This intention is a function of the attitude toward the behavior and the subjective norm (Ajzen, 1991).
Personality (I)	According to Feist and Feist (Feist, 1994) personality is a pattern of relatively permanent traits and unique characteristics that give both consistency and individuality to a person's behavior.
Type A(B) personality (I)	Defines two contrasting personality types, where type A individuals are ambitious, rigidly organized, highly status-conscious, impatient and want other people to get to the point and type B persons are quite the opposite and have a lower stress level and enjoying achievement but do not become stressed when they do not achieve. Originally, in the 1950s cardiologists Meyer Friedman and Ray Rosenman described type A behavior as a potential risk factor for heart disease. (Friedman and Rosenman, 1959).
Work life balance (I)	Clark views worklife balance as satisfaction and good functioning at work and at home with a minimum of role conflict (Clark, 2000).
Workplace happiness index (I)	A measure that indicates an individual's level of satisfaction with the experience of work on a personal, psychological level (Albano, 2009).
Intentions to leave (I)	Refers to conscious and deliberate willfulness to leave the organization (Tett and Meyer, 1993).
Loyalty (I)	Can be described as devotion or faithfulness towards something - e.g. person, group or company. Loyalty involves both dedication and consistency (Lee and Graefe, 2001).
Alienation (G)	Is as a state of mind, a subjective feeling that can vary between individuals in the following for dimensions; powerlessness, meaninglessness, isolation and self-estrangement (ODonohue et al., 2014).
Cohesion (G)	The degree to which those in a social system identify with it and feel bound to support it (Durkheim, 2014).
Communication (G)	The process that allows people to exchange information, feeling or thoughts (Katz and Kahn, 1978).
Conformity (G)	Defined by Crutchfield in 1955 as simply as yielding to group pressures (Crutchfield, 1955).
Deindividuation (G)	The loss of self awareness and of individual accountability in a group (Psychwiki, 2014).
Diffusion of responsibility (G)	A phenomenon in which people are less likely to take action or less likely to feel a sense of responsibility in a large group of people (Latane and Darley, 1968).
Group composition (G)	Is the configuration of member attributes in a team/group (Bell, 2007).
Decision making (G)	Is the process of choosing between alternatives or as selecting/rejecting available options (A.P. Association, 2014).
Group development (G)	Describes how and why groups develop and evolve (Adnan et al., 2013).
Group dynamics (G)	Is a system of behaviors and psychological processes that occurs within a group or between groups (Forsyth, 2009).
Group processes (G)	Is Group processes concerns the cognitive and social causes and consequences of human aggregation (Smelser and Baltes, 2001).
Group polarization (G)	Is the tendency for groups to make decisions that are more extreme than the decisions that would be made by the members acting alone (A.P. Association, 2014).
Group social identity (G)	Defined by Hogg and Vaughan as an self-concept derived from perceived membership of social groups, i.e. the aspects of a person that are defined in terms of his or her group memberships (Hogg and Vaughan, 2002).
Group think (G)	The tendency of a decision-making group to filter out undesirable input so that a consensus may be reached, especially if it is in line with the leader's viewpoint (A.P. Association, 2014).
Intergroup behavior (G)	Behavior that involves interaction between members of distinct social groups (Hogg and Vaughan, 2002).
Leadership (G)	Is the art of influencing followers to achieve success by identifying joint goals, finding best-fit roles in teams, collaborating constructively and dynamically, and adapting to change within their environments (Wikipedia, 2014).
Group norms (G)	Are informal rules that regulates the behavior of the group (Feldman, 1984).
Organizational climate (O)	Is defined as the recurring patterns of behavior, attitudes and feelings that characterize life in the organization (Isaksen et al., 2007; Denison, 1996).
Organizational culture (O)	Organizational culture is the behavior of humans within an organization and the meaning that people attach to those behaviors (Denison, 1996; Isaksen et al., 2007).
Organizational change (O)	Is both the process in which an organization changes and the effects of these changes on the organization (Portal, 2014).
Organizational learning (O)	Refers to models, theories and processes about the way an organization learns new knowledge (Argyris and Schon, 1997; Simon, 1965).

Table 8
BSE concepts and search string.

BSE concept (UoA)	Search string
Cognitive style	(“cognitive style” OR “thinking style” OR “adaption-innovation”)
Cognitive affective personality system	(“cognitive-affective personality system” OR “cognitive affective processing system” OR “CAPS”)
Dunning–Kruger effect	(“dunning–kruger effect” OR “dunning kruger effect”)
Demand-control	(“demand-control model” OR “demand control model”)
Explanatory style	(“explanatory style” or “attributional style”)
Innovation diffusion theory	(“diffusion of innovations” or “innovation diffusion theory”)
Job insecurity	(“job insecurity”)
Job satisfaction	(“job satisfaction”)
Goal orientation theory	(“goal orientation”)
Life satisfaction	(“life satisfaction”)
Locus of control	(“locus of control”)
Motivation	(“motivation”)
Need theory	(“McClelland” or “need theory” or “needs theory”)
Organizational commitment	(“organizational commitment” or “organisational commitment”)
Positive psychology	(“positive psychology” or “flow”)
Risk taking	(“taking risks” or “risk taking” or “risk-taking” or “risk aversion” or “risk seeking” or “risk-seeking”)
Self control	(“self control” or “self-control” or “self regulation” or “self-regulation”)
Self discipline	(“self discipline” or “self-discipline”)
Self efficacy	(“self efficacy” or “self-efficacy”)
Self esteem	(“self esteem” or “self-esteem”)
Self monitoring	(“self-monitoring” or “self monitoring”)
Social value orientation	(“social value orientation”)
Stereotypes	(“stereotypes” or “stereotype”)
Stress	(“stress” or “stressors” or “burnout” or “burn out” or “burn-out”)
Theory X theory Y	(“theory x” or “theory y”)
Theory of reasoned action	(“theory of reasoned action” or “theory of planned behavior”)
Technology acceptance model	(“technology acceptance model”)
Personality	(“personality” or “trait”)
Type A(B) personality	(“type a personality” or “type b personality” or “type-a personality” or “type-b personality”)
Work life balance	(“work-life balance” or “work life balance”)
Workplace happiness index	(“workplace happiness index”)
Intentions to leave	(“intention to leave”)
Loyalty	(“loyalty”)
Alienation	(“alienation”)
Cohesion	(“cohesion” or “cohesiveness”) AND (”team” or “group”)
Communication	(“communication”)
Conformity	(“conformity”) AND (”group” or “team”)
Conflicts	(“conflicts”)
Deindividuation	(“deindividuation” or “SIDE model” or “SIDE theory”)
Diffusion of responsibility	(“diffusion of responsibility”)
Group composition	(“team composition” or “group composition” or “team design” or “group design”)
Decision making	(AB(”decision making”))
Group development	(“group development” or “group formation”)
Group dynamics	(“group dynamics”)
Group processes	(“group processes”)
Group polarization	(“group polarization”)
Group social identity	(“social identity”)
Group think	(“group think” or “groupthink” or “group-think”)
Intergroup behavior	(“intergroup” or “intragroup”)
Leadership	(“leadership”)
Group norms	(“group norms”) or (“group norm”)
Organizational climate	(“organizational climate” or “organisational climate”)
Organizational culture	(“organizational culture” or “organisational culture”)
Organizational change	(“organizational change” or “organisational change”)
Organizational learning	(“organizational learning” or “organisational learning”)

Table 9
The table shows: (1) index number and abbreviation, (2) the BSE concepts and unit of analysis, (3) the number of included publications, (4) number of search result for Google Scholar, IEEE Digital Library, ACM Xplore Digital Library and PsycINFO, respectively, that were included for further screening, (5) reference to the included publications.

Abr	BSE concept (UoA)	No.	Search result	Publications
1 CS	Cognitive style (I)	10	2880 8 45 4	(Sultan and Chan, 2000; White and Sivitanides, 2002; Jablokow and Myers, 2010; Gallivan, 1998; Rui et al., 2011; Mancy and Reid, 2004; Choi, 2007; Agarwal and Prasad, 2000; Chilton et al., 2005; Rui et al., 2011)
2 CAPS	Cognitive affective personality system (I)	0	11 0 0 0	
3 DKE	Dunning–Kruger effect (I)	0	20 0 2 0	
4 DC	Demand-control (I)	3	200 0 1 0	(Schreurs and Taris, 1998; Shen and Gallivan, 2004; Wallgren and Hanse, 2007)

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Table 9 (*continued*)

Abr	BSE concept (UoA)	No.	Search result	Publications
5 ES	Explanatory style (I)	1	120 0 1 0	(Jørgensen et al., 2007)
6 IDT	Innovation diffusion theory (I)	6	6210 8 0 3	(Green and Hevner, 2000; Lim et al., 2000; Woo et al., 2006; Beynon-Davies and Williams, 2003; Hardgrave and Johnson, 2003; Dysart-Gale et al., 2011)
7 JI	Job insecurity (I)	7	826 1 5 0	(Agarwal and Prasad, 1997; França et al., 2011; Smith et al., 2010; Lin and Ding, 2003; Agarwal and Prasad, 2000; Li et al., 2000; Tessem and Maurer, 2007)
8 JS	Job satisfaction (I)	24	8700 11 104 19	(Ozer, 2008; Calisir et al., 2009; Dybå and Dingsøyr, 2008; Tseng and Wallace, 2012; Scholarios and Marks, 2004; Lee et al., 2008; Gallivan, 1998; Westlund and Hannon, 2008; Pedrycz et al., 2011; Linberg, 1999; Lee and Gallivan, 2011; Melnik and Maurer, 2006; Mourmant and Gallivan, 2007; Schreurs and Taris, 1998; Jain, 2010; Judge et al., 2002; Succi et al., 2002; Chen, 2008; Sach and Petre, 2012; Khan et al., 2012; Shen, 2005; Buche, 2008; Janz, 1999; Acunã et al., 2009)
9 GOT	Goal orientation theory (I)	3	2260 13 48 4	(Darcy and Ma, 2005; Sonnentag et al., 1997; Hardgrave and Johnson, 2003)
10 LS	Life satisfaction (I)	0	864 0 3 0	
11 LOC	Locus of control (I)	3	3060 5 48 2	(Ozer, 2008; Darcy and Ma, 2005; Calisir et al., 2009)
12 MOT	Motivation (I)	12	na na na na	(Ohly and Fritz, 2007; Hall et al., 2009; Wallgren and Hanse, 2007; França et al., 2011; Sach and Petre, 2012; McLeod and MacDonell, 2011; Stenmark, 2002; Janz, 1999; Siau et al., 2010; Tessem and Maurer, 2007; Beecham et al., 2008; Sharp et al., 2009)
13 NT	Need theory (I)	3	154 0 3 0	(Seger et al., 2008; Hall et al., 2009; Sach and Petre, 2012)
14 OC	Organizational commitment (I)	10	3620 5 41 3	(Calisir et al., 2009; Scholarios and Marks, 2004; Kumar and Thangavelu, 2013; Bin Basri and O'Connor, 2010; Stavru, 2012; Abrahamsson, 2001; Arya et al.; Singh et al., 2012; Lee et al., 2008; Demir, 2009)
15 PP	Positive psychology (I)	2	938 0 10 0	(Graziotin et al., 2013; Zarb, 2011)
16 RT	Risk taking (I)	2	14100 13 118 9	(Host and Lindholm, 2007; Fisher et al., 2006)
17 SC	Self control (I)	0	9710 16 119 3	
18 SD	Self discipline (I)	0	1980 10 26 0	
19 SEFF	Self efficacy (I)	14	7370 13 161 6	(Ohly and Fritz, 2007; Darcy and Ma, 2005; Tsai and Cheng, 2010; Ramalingam et al., 2004; Seger et al., 2008; Giannakos et al., 2012; Lopez et al., 2008; Yang and Cheng, 2009; Ambrose and Chiravuri, 2010; Dunlap, 2005; Sethuraman and Medley, 2009; Mellarkod et al., 2007; Arya et al.; Trimmer et al., 1998)
20 SEST	Self esteem (I)	6	7330 5 97 1	(Lopez et al., 2008; Williams et al., 2006; Katira et al., 2004; Katira et al., 2005; Salleh et al., 2011; White and Sivitanides, 2002)
21 SM	Self monitoring (I)	0	3690 15 117 0	
22 SVO	Social value orientation (I)	0	51 0 1 1	
23 STE	Stereotypes (I)	8	8660 25 206 5	(Lopez et al., 2008; Capretz, 2003; Beaubouef and Zhang, 2011; Ruslanov and Yolevich, 2010; Williams, 2005; Garcia-Crespo et al., 2008; Grant et al., 2007; Capretz, 2008)
24 STR	Stress (I)	12	18900 6 116 12	(Calisir et al., 2009; Maudgalya et al., 2006; Singh et al., 2012; Zadeh and Begum, 2011; Singh and Suar, 2013; Taris et al., 1999; Nishikitani et al., 2005; Hallberg et al., 2007; Wallgren and Hanse, 2007; Schreurs and Taris, 1998; Smith et al., 2010; Adya, 2008)
25 TXY	Theory X theory Y (I)	0	852 1 13 0	
26 TRA	Theory of reasoned action (I)	5	3070 6 34 1	(Hardgrave and Johnson, 2003; Umarji and Seaman, 2005; Passos et al., 2013; Darehshori and Mohamed, 2013; Riemenschneider et al., 2002)
27 TAM	Technology acceptance model (I)	16	5870 29 106 6	(Giannakos et al., 2012; Mellarkod et al., 2007; Agarwal and Prasad, 1997; Riemenschneider and Hardgrave, 2001; Polančič et al., 2011; Ciolkowski et al., 2007; Hardgrave and Johnson, 2003; Overhage et al., 2011; Davis and Venkatesh, 2004; Keung et al., 2004; Umarji and Seaman, 2005; Darehshori and Mohamed, 2013; Agarwal and Prasad, 2000; Hardgrave et al., 2003; Chan and Thong, 2009; Riemenschneider et al., 2002)
28 TRAIT	Personality (I)	31	na na na na	(Darcy and Ma, 2005; Williams et al., 2006; Katira et al., 2004; Katira et al., 2005; Salleh et al., 2011; Dybå and Dingsøyr, 2008; Hall et al., 2009; Cruz et al., 2011; Capretz, 2003; Choi, 2007; Lounsbury et al., 2009; Choi et al., 2009; Mourmant and Gallivan, 2007; Judge et al., 2002; Licorish et al., 2009; Lewis and Smith, 2008a, 2008b; Pieterse et al., 2006; Kang et al., 2006; Omar and Syed-Abdullah, 2010; Bradley and Hebert, 1997; Karn et al., 2007; Peslak, 2006; Gelade and Gilbert, 2003; Lewis and Smith, 2008a, 2008b; Rutherfoord, 2001; Sfetsos et al., 2006; Feldt et al., 2008; Acunã et al., 2009; Gorla and Lam, 2004; da Silva et al., 2011; Trimmer et al., 1998)
29 TABP	Type A(B) personality (I)	3	108 2 0 0	(Lee et al., 2008; Hallberg et al., 2007; França et al., 2011)
30 WLB	Work life balance (I)	5	1940 2 0 0	(Tseng and Wallace, 2012; Scholarios and Marks, 2004; Bal, 2010; Pandu and Balu, 2013; Adya, 2008)
31 WHI	Workplace happiness index (I)	0	0 0 0 0	
32 ITL	Intentions to leave (I)	2	na na na na	(Ghapanchi and Aurum, 2011; Buche, 2008)
33 LOY	Loyalty (I)	1	16800 26 189 0	(Ang and Slaughter, 2006)
34 A	Alienation (G)	2	4150 3 38 1	(Ang and Slaughter, 2006; Adya, 2008)
35 OCH	Cohesion (G)	17	17100 171 1114 9	(Dybå and Dingsøyr, 2008; McAvoy, 2006; McAvoy and Butler, 2009; Bradley and Hebert, 1997; Hoegl and Gemuenden, 2001; Sarker and Schneider, 2009; Wellington et al., 2005; Ocker, 2002; Stenmark, 2002; Ramasubbu et al., 2012; Yang and Tang, 2004; Hoegl et al., 2003; Bahli and Buyukkurt, 2005; Last, 2003; Hoegl and Parboteeah, 2007; Karn et al., 2007; Lohan et al., 2013)

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Table 9 (*continued*)

Abr	BSE concept (UoA)	No.	Search result	Publications
36 COM	Communication (G)	39	17400 917 1001 263	(Salleh et al., 2011; Choi, 2007; Pedrycz et al., 2011; Choi et al., 2009; Lewis and Smith, 2008a, 2008b; Burton et al., 2011; Lasser and Heiss, 2005; Dullemond et al., 2013; Ikonen and Kurhila, 2009; Lowry et al., 2010; McLeod and MacDonell, 2011; Demir, 2009; Bradley and Hebert, 1997; Hoegl and Gemuenden, 2001; Chang et al., 2010; Swigger et al., 2012; Sonnentag, 2000; Sawyer and Guinan, 1998; Gelade and Gilbert, 2003; Mishra and Mishra, 2009; Gallivan and Keil, 2003; Brodbeck, 2001; Siau et al., 2010; Napier et al., 2009; Pine and Barrett, 2005; Seaman and Basili, 1998; Dysart-Gale et al., 2011; Suchan and Hayzak, 2001; Seaman and Basili, 1997; Herbsleb and Mockus, 2003; Layman et al., 2006; Pikkarainen et al., 2008; Andres, 2002; Dutoit and Bruegge, 1998; Jiménez et al., 2009; Colomo-Palacios et al., 2013; Wakefield et al., 2008; Sfetsos et al., 2006; Cataldo and Ehrlich, 2012)
37 CONFO	Conformity (G)	4	16400 31 299 2	(Sultan and Chan, 2000; Last, 2003; Lin and Huang, 2010; Sawyer and Guinan, 1998)
38 CONFL	Conflicts (G)	23	16700 317 3746 26	(Lewis and Smith, 2008a, 2008b; McLeod and MacDonell, 2011; Ocker, 2002; Yang and Tang, 2004; Chang et al., 2010; Seeber, 2013; Sassenburg, 2006; Sawyer, 2001; Steinmacher et al., 2013; Domino et al., 2003; Zhang et al., 2007; Trimmer et al., 2000; Wakefield et al., 2008; Sukhoo et al., 2005; Leidner and Kayworth, 2006; CHEN et al., 2011; Liang et al., 2010; Gobeli et al., 1998; Liu et al., 2011; Dewan and Hegde, 2007; Lewis and Smith, 2008a, 2008b; Acuñ et al., 2009; Wieland et al., 2013)
39 DEIND	Deindividuation (G)	0	188 1 22 0	
40 DOR	Diffusion of responsibility (G)	3	218 0 6 0	(Leveson, 2004; Flechais et al., 2003; Gotterbarn, 2001)
41 GC	Group composition (G)	24	8000 18 256 3	(Licorish et al., 2009; Lewis and Smith, 2008a, 2008b; Burton et al., 2011; Lasser and Heiss, 2005; Dullemond et al., 2013; Melo et al., 2011; Ikonen and Kurhila, 2009; Tinelli et al., 2012; Monteiro et al., 2011; Pieterse et al., 2006; Senapathi and Srinivasan, 2013; Kang et al., 2006; Lowry et al., 2010; Omar and Syed-Abdullah, 2010; da Silva et al., 2013; Sudhakar et al., 2011; McLeod and MacDonell, 2011; Thomas, 1999; Peslak, 2006; Liang et al., 2007; Rutherfoord, 2001; Rajendran, 2005; Gorla and Lam, 2004; da Silva et al., 2011)
42 DM	Decision making (G)	7	16200 155 18 87	(Lin and Ding, 2003; Sassenburg, 2006; Colomo-Palacios et al., 2013; Ribeiro et al., 2011; Nguyen, 2006; Lohan et al., 2013; Moe and Aurum, 2008)
43 GDEV	Group development (G)	8	4270 11 0 1	(Last, 2003; Hoegl and Parboteeah, 2007; Chang et al., 2010; Janz, 1999; Mcgrew et al., 1999; Ounnas et al., 2007; Ocker, 2001; Napier et al., 2009)
44 GDYN	Group dynamics (G)	12	6860 9 175 16	(Linberg, 1999; Hoegl and Gemuenden, 2001; Faraj and Yan, 2009; Ang and Slaughter, 2006; Yang and Tang, 2004; Last, 2003; Hoegl and Parboteeah, 2007; Chang et al., 2010; Seeber, 2013; Rosen, 2005; Thomas, 1999; Sawyer, 2001; Teh et al., 2012)
45 GPRO	Group processes (G)	10	4360 3 98 0	(Williams, 2005; Hoegl and Gemuenden, 2001; Faraj and Yan, 2009; Ang and Slaughter, 2006; Yang and Tang, 2004; Last, 2003; Chang et al., 2010; Seeber, 2013; Moløkken-Østvold and Jørgensen, 2004; Piri, 2008)
46 GPOL	Group polarization (G)	0	221 0 3 0	
47 GSI	Group social identity (G)	5	3070 2 47 2	(Whitworth, 2008; Ager, 2011; Whitworth and Biddle, 2007; Buche, 2008; Chang et al., 2010)
48 GT	Group think (G)	2	2570 2 1 1	(McAvoy, 2006; McAvoy and Butler, 2009)
49 IB	Intergroup behavior (G)	1	4150 5 67 2	(Rosen, 2005)
50 LEAD	Leadership (G)	23	16100 255 1341 29	(Sultan and Chan, 2000; Tseng and Wallace, 2012; Akman et al., 2011; França et al., 2011; Sudhakar et al., 2011; McLeod and MacDonell, 2011; Demir, 2009; Bradley and Hebert, 1997; Sarker and Schneider, 2009; Rosen, 2005; Peslak, 2006; Napier et al., 2009; Faraj and Sambamurthy, 2006; Royce, 2005; Eseryel and Eseryel, 2013; Tansley and Newell, 2007; Gumusluoglu and Ilsev, 2009; Wakefield et al., 2008; Dhomne and Hall, 2012; Tevis and Rouse, 2010; Agrawal and Thite, 2003; Tuffley, 2012; Sukhoo et al., 2005)
51 GNOR	Group norms (G)	1	1360 1 21 0	(Teh et al., 2012)
52 OCLI	Organizational climate (O)	7	2640 2 15 13	(Tsai and Cheng, 2010; Tan et al., 2003; Sudhakar et al., 2011; Clincy, 2003; Janz, 1999; Mathew et al., 2011; Trimmer et al., 1998)
53 OCUL	Organizational culture (O)	21	16600 48 197 6	(Sultan and Chan, 2000; Dybå and Dingsøyr, 2008; Passos et al., 2013; Shih and Huang, 2010; Verma and Amin, 2010; Iivari and Abrahamsson, 2002; Boden et al., 2009; Robinson and Sharp, 2005; Ngwenyama and Nielsen, 2003; Siakas, 2002; Mûller et al., 2009; Campbell et al., 2013; Strode et al., 2009; Iivari and Huisman, 2007; Tolfo et al., 2011; Sudhakar et al., 2011; Suchan and Hayzak, 2001; Leidner and Kayworth, 2006; Dubé and Robey, 1999; Iivari and Iivari, 2011; Dubé, 1998)
54 OCHA	Organizational change (O)	8	17200 40 200 17	(Lavallée and Robillard, 2012; Thomas et al., 2011; Dirksen et al., 2005; Strens and Chudge, 1998; Nerur et al., 2005; Gandomani et al., 2013; Unterkalmsteiner et al., 2012; Pino et al., 2008)
55 OLEAR	Organizational learning (O)	3	na na na na	(Dirksen et al., 2005; Robey et al., 2000; Bjørnson and Dingsøyr, 2008)

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